

도심로와 자동차전용도로에서의 자율주행 돌발 종료 상황의 청각 알림 비교 연구

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Comparison of Auditory Alarms Considering Unplanned ODD Exit and Road Types in Conditionally Automated Driving

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Abstract : A human-in-the-loop experiment was conducted with a vehicle simulator and 40 volunteers who evaluated the auditory alarms that were conveying driving situations to drivers before a request for a takeover was submitted. The study compared driver sensitivity in Unplanned ODD Exit situations(over-speeding and off-route), road types(motorway and city road), and auditory alarms(speech and earcons + speech). Driver sensitivity was measured according to situation awareness, anxiety, reliability, suitable duration, and preferred alarm. The appropriate auditory alarm and duration were determined for each situation and road type based on those measurements. The results showed that drivers had higher situation awareness and reliability and lower anxiety in over-speeding situations than in off-route situations. Most drivers preferred earcons + speech over plain speech, with 6 seconds being rated as the most suitable duration, presumably because all auditory alarms lasted for 6 seconds during the test. The results were used to develop interface information design guidelines for automated driving systems from the driver's point of view.

Key words : Auditory alarm(청각 알림), Automated vehicle(자율주행차량), Operational design domain(운행설계영역), Unplanned ODD exit(ODD 이탈), Information provision(정보 제공)

Nomenclature

CID : center information display
 MRC : minimal risk condition
 ODD : operational design domain
 TOR : take over request

1. 서 론

운행설계영역(Operational Design Domain, ODD)은 자율주행 시스템이 작동하도록 설계된 특정 운영 영역이다.¹⁾ SAE J3016에 따르면, 자율주행 레벨 5(완전 자율주행)에서는 ODD에 한계가 없지만, 자율주행 레벨 4(고도화 자율주행), 레벨 3(조건부 자율주행), 그리고 그

이하의 레벨에서는 ODD에 한계가 있다.²⁾

자율주행 중 차량이 ODD를 벗어난 경우를 ‘ODD 종료’라고 한다. ODD 종료 시, 자율주행 시스템은 운전자에게 개입을 요청하거나 스스로 최소위험조건(Minimal Risk Condition, MRC)에 도달해야 한다. 레벨 3의 경우, ODD 종료 시, 차량 혹은 시스템 고장 시, 자율주행 시스템이 적시에 비상대비책을 갖춘 운전자에게 개입을 요청해야 하며, 운전자 또한 개입 요청에 수용성을 갖고 적시에 비상대비책을 수행함으로써 개입 요청에 대응한다.²⁾ 레벨 4의 경우, ODD 종료 시, 차량 혹은 시스템 고장 시, 운전자가 개입 요청에 반응하지 않을 시, MRC로 전환할 것을 운전자가 요청할 시, 자율주행 시스템은 비상대비책을 수행하고 자동으로 MRC로 전환해야 한

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